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Science and Technology for Tomorrow's Air and Space Force

Success Story

ADVANCES IN NET-SHAPE POWDER METALLURGY

Successful development of powder metallurgy (PM) bladed disk or "blisk" fabrication methods, incorporating high-strength, environmentally compatible superalloys, enables revolutionary advances in turbopump rotating-element materials and designs. New materials and fabrication methods enable the aerospace industry to manufacture cryogenic-compatible turbine blisks combining the highest performing nickel-base super alloy turbine materials, normally reserved for airbreathing gas turbine engines, with the high reliability and low maintenance of the typical low-strength super alloys.

Continuing research is leading to important innovations in hot isostatic pressing (HIP) technology for net-shape PM parts. These include extensive use of very-high-strength alloys difficult to produce using conventional manufacturing methods, avoiding welds, and providing functionally optimized local alloy composition variations.

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Accomplishment

The Materials and Manufacturing Directorate, working with industry, has made significant advancements in the development of new fabrication methods and protective coating processes for high-performance, low-cost, net-shape PM components for aircraft and rocket engines. Net-shape PM has intrigued researchers and industry for more than 40 years because it eliminates complex machining operations, thereby reducing costs.

Working with Boeing Rocketdyne and LNT USA, the directorate's Metals, Ceramics, and Nondestructive Evaluation Division is developing rotating pump component materials and processes for turbine engines that can trim parts' weight by 35%, reduce production costs by 45%, and lower the projected costs of fabricating a net-shape PM-manufactured blisk by more than 40%.

Background

Manufacturers fabricate turbine rotors used to propel jet aircraft and rockets from forged disks with mechanically attached cast blades, or they machine them from one-piece forgings. The state-of-the-art method for manufacturing the disks is to build them from either conventional high-strength, nickel-base super alloys and coat them for environmental protection or manufacture them from moderate strength alloys fully compatible in the applicable environment.

Coatings introduce reliability and cost issues, while the moderate strength alloys sacrifice performance. Net-shape PM is a method for "casting" with solid metal powder and consolidating to a net shape, which combines inherent design and processing benefits with the performance benefits of forgings to produce parts with structure and properties comparable to forgings.

Boeing Rocketdyne, supported by the directorate and LNT USA, has developed a technology for fabricating a high, specific-strength blisk made via selective net shape (SNS) PM processing with an environmentally compatible HIP-bonded surface layer. The SNS PM process uses a precision-machined, low carbon steel mold, analogous to an investment-casting mold.

LNT USA machines the part details into a mold, which are assembled; welded into a capsule; and then filled with metal powder, evacuated, and hot isostatically pressed (HIP'd) to compact the powder. LNT USA then uses conventional machining and chemical milling to remove the carbon steel tooling.

Materials and Manufacturing
Emerging Technologies

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-ML-42)